Article

Radiographic and functional evaluation of dogs at least 1 year after tibial plateau leveling osteotomy

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Abstract — The progression of osteoarthritis and clinical function in 29 dogs at least 1 year after tibial plateau leveling osteotomy was evaluated. A previously reported radiographic scoring system was used by 3 investigators to evaluate preoperative and postoperative radiographs for evidence of stifle osteoarthritis. The combined scores were then used to evaluate the progression of osteoarthritis. The difference between the preoperative scores, derived from radiographs taken at the time of surgery, and the postoperative scores based on radiographs taken at least 1 year later was modest but statistically significant. Despite this finding, client satisfaction was very good. Clinical function was assessed by using a previously reported client questionnaire. According to owner assessment at least 1 year after surgery, there was a significant improvement in function after tibial plateau leveling osteotomy when compared with the preoperative status. Improvement in function as measured by the client questionnaire did not significantly predict the radiographic osteoarthritis score.

Résumé — Évaluation radiographique et fonctionnelle de chiens au moins 1 an après une ostéotomie par nivellement du plateau tibial. La progression de l'ostéoarthrite et le fonctionnement clinique de 29 chiens ont été évalués au moins un an après une ostéotomie par nivellement du plateau tibial. Un système de cotation radiographique préalablement décrit a été utilisé par 3 investigateurs afin d'évaluer des radiographies pré et post opératoires comme preuve d'ostéoarthrite du grasset. Les cotations combinées ont alors été utilisées pour évaluer la progression de l'ostéoarthrite. Les différences entre les cotations préopératoires, obtenues à partir de radiographies prises au moment de la chirurgie et les cotations postopératoires basées sur des radiographies prises au moins 1 an plus tard, étaient faibles mais statistiquement significatives. En dépit de ces constatations, la satisfaction des clients était très bonne. La fonction clinique a été évaluée à l'aide d'un questionnaire préalablement décrit rempli par les clients. Selon l'évaluation des propriétaires, au moins 1 an après la chirurgie, il y avait une amélioration significative du fonctionnement après l'ostéotomie par nivellement du plateau tibial par comparaison avec l'état préopératoire. L'amélioration du fonctionnement tel que mesuré par le questionnaire rempli par les clients ne présentait pas de relations significatives avec les cotations radiographiques de l'ostéoarthrite.

(Traduit par Docteur André Blouin)

Introduction

The cranial cruciate ligament is the primary craniocaudal stabilizer of the stifle through most of its range of motion. It prevents internal rotation and cranial translation of the tibia (1–3). Rupture of the cranial cruciate ligament is a very common pelvic limb injury in dogs (1–3). It is most often reported in middle-aged dogs; however, 1 study reports a trend toward younger dogs developing the condition (4). Cranial cruciate ligament injury in dogs is more often insidious in onset due to a gradual deterioration of the ligament and less often associated with an acute traumatic rupture (2,5). It has been well documented that untreated rupture of the cranial cruciate ligament leads to degenerative changes in the stifle (5–9), especially for dogs weighing more than 15 kg (5,10).

Many surgical techniques have been described to stabilize the cranial cruciate ligament deficient stifle; most fall into the category of extracapsular or intracapsular substitution techniques (11–16), and good clinical outcomes with these techniques have been reported (11,14–20). Other reports have noted progression of radiographic osteoarthritis (OA) after stabilization, despite an acceptable clinical outcome (10,15–17,21–24). Tibial plateau leveling osteotomy (TPLO), as described by Slocum (25), neutralizes the effects of uncontrolled cranial tibial thrust in the weight bearing cranial cruciate deficient stifle by leveling the tibial plateau. The functional stifle stability provided by this technique has been reported to minimize the progression of OA (25). Few studies have attempted to document the radiographic progression of OA after TPLO (26–28). So the purpose of this study was to measure the radiographic changes of OA in dogs a minimum of 1 y after unilateral TPLO surgery. Postoperative function was also assessed by a client questionnaire.

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Table 1. Modified radiographic score catagories (22)

Radiographic category	0 (absent)	1 (minimal)	2 (mild)	3 (moderate)	4 (severe)
Proximal patella osteophytes					
Distal patella osteophytes					
Femoral trochlear groove periarticular osteophytes					
Femoral supratrochlear lysis					
Lateral femoral condylar periarticular osteophytes					
Medial femoral condylar periarticular osteophytes					
Femoral subchondral sclerosis					
Central femoral metaphyseal subchondral cystic lucencies					
Intercondyloid fossa subchondral cystic lucencies					
Femoral condyle subchondral cystic lucencies					
Lateral gastrocnemius fabellar periarticular osteophytes					
Medial gastrocnemius fabellar periarticular osteophytes					
Popliteal sesamoids periarticular osteophytes					
Medial periarticular osteophytes of the proximal tibia					
Lateral periarticular osteophytes of the proximal tibia					
Cranial periarticular osteophytes of the proximal tibia					
Caudal periarticular osteophytes of the proximal tibia					
Medial subchondral sclerosis of the proximal tibia					
Lateral subchondral sclerosis of the proximal tibia					
Subcondral cystic lesions of the proximal tibia					
Central tibial plateau osteophytes					
Joint effusion/capsular thickening					
Lateral soft tissue thickening					
Medial soft tissue thickening					
Intraarticular mineralized osseous fragments					
Meniscal mineralization					
Intercondylar avulsion fracture fragments					
Patellar ligament thickening					
Extensor fossa osteophytes					

Materials and methods

Animal selection

Owners of dogs over 15 kg (range, 18.4–51.2 kg) that had had TPLO surgery at least 1 y before commencement of the study were invited to enroll their animals. One hundred and two invitations were extended. Dogs with other orthopedic, neurological, or systemic problems, as determined by physical examination, were excluded from the study. Twenty-nine dogs of mixed age, gender, and breed were eventually enrolled.

Radiographic evaluation

Radiographs had been taken prior to each TPLO surgery. Follow up radiographs were taken at least 1 y after surgery (range 12 to 33 mo, mean 20.6 mo). Standard mediolateral and craniocaudal or caudocranial projections, as described by Slocum, were available for each dog just prior to and at least 1 y after surgery (29). The labels were obscured and the radiographs placed in blank envelopes marked preoperative and postoperative, so that the observers were blind to the identity of the individual dogs: 3 observers; a board certified radiologist (SE); a board certified surgeon (CM); and a small animal surgery resident (DB), assessed the radiographs independently. Radiographic evidence of stifle OA was scored using a system described by Vasseur (22). The system was modified slightly for this study by adding a category for extensor fossa osteophytes and removing the categories of enthesiopathy of the lateral and medial collateral ligaments (Table 1). Twenty-nine categories were assessed. Degenerative changes for each category were recorded as 0 = absent, 1 = minimal, 2 = mild, 3 = moderate, and 4 = severe. The absolute radiographic score could range between 0 and 116. Each observer's scores were compared. Agreement between each radiographic observer was assessed by using the coefficient of concordance. The combined mean radiographic score was used as the official radiographic score for each dog, as there was a high percentage of agreement between observers. The differences between preoperative and postoperative radiographic scores were evaluated by using a paired Wilcoxon signed rank test.

Scores were then assigned to 1 of 2 groups in order to reflect clinical relevance. Dogs with a radiographic score change of < 5 were classified as improved or no change. Dogs with a radiographic score change > 5 were considered to have worsened (26).

Client questionnaire

A questionnaire based on the Bristol OA in dogs (BrOAD) questionnaire (24) was given to the owners of the dogs included in the study (Figure 1). Owners of all included dogs returned the questionnaires. The first 4 questions related to preoperative function. The next 4 were similar questions relating to postoperative function. Each answer was plotted on a 100 mm visual analogue scale. The scales were modified, so that a score of 0 was the most negative result, while a score of 100 was the most positive result. The summed scores of the preoperative questions were compared with the sum of the postoperative questions by using a Wilcoxon signed rank test. The sum of the postoperative questions was compared with dichotomized radiographic outcome data by using logistic regression.

Lameness evaluation

Dogs were evaluated for lameness at a walk and trot at least 1 y after the TPLO surgery by 1 veterinarian (DB).

Figure 1. Client questionnaire (24)

Part 1: The situation before your dog had a problem:

1. How active was your dog?

   Not active ——————————————— Always exercising

Part 2: The situation before you visited Dr. Miller:

1. How would you grade the overall disabling effects of your dog's problem before surgery?

   No disability ——————————————— Completely disabled

2. Did your dog suffer stiffness after a lie down?

   No stiffness ——————————————— Extreme stiffness

3. What was the effect of the symptoms of cold, damp weather?

   No effect ——————————————— Much worse

4. How well could your dog jump?

   Unable ——————————————— No problem

Part 3: The situation one year after surgery:

1. How disabled is your dog *now*?

   Much worse ——————————————— Completely recovered

2. Does your dog suffer stiffness after a lie down *now*?

   No stiffness ——————————————— Extreme stiffness

3. What effect does cold, damp weather have *now*?

   No problem ——————————————— Much worse

4. How active is your dog *now*?

   Not active ——————————————— Always exercising

Statistics

A statistical analysis system (SAS OnlineDoc, version 8; SAS Institute, Cary, North Carolina, USA) was used to compute univariate analysis, including a Shapiro-Wilk test and Levene's test to determine normal distribution of the data. For all statistical tests, significance was set at $P < 0.05$.

Results

All 29 dogs were neutered/spayed (16 female and 13 male). Breeds that were represented included Labrador retriever (9), boxer (4), rottweiler mix (3), springer spaniel (3), Bernese mountain dog (1), golden retriever (1), Border collie (1), Rhodesian ridgeback (1), Labrador retriever mix (1), vizsla (1), Chesapeake bay retriever (1), German shepherd mix (1), and German short-haired pointer (1). Dogs weighed an average of 33.6 kg (range, 18.4–51.2 kg) and ranged in age from 16 mo to 11 y 9 mo, with a mean of 4 y 1 mo. Duration of lameness prior to surgery ranged from 1 wk to 156 wk, with a mean of 19.5 wk. The left pelvic limb was affected in 17 dogs and the right pelvic limb in 12 dogs. Four dogs had a previous extracapsular stabilization prior to the TPLO. A standard medial parapatellar arthrotomy was performed in 24 dogs (30). A smaller caudal arthrotomy, as described by Slocum (25), was performed in the remaining 5 dogs. Twelve of the 29 dogs had meniscal injuries, 11 affecting the medial meniscus and 1 affecting the lateral meniscus. Partial meniscectomies were performed in all 12 affected cases. Caudal medial meniscal releases were performed in the 17 dogs with no identified meniscal lesions.

The coefficient of concordance between SE and DB was $\rho c = 0.892$; between SE and CM was $\rho c = 0.952$, and between CM and DB was $\rho c = 0.954$. The combined (SE, CM, DB) mean postoperative radiographic score 35.17 was significantly greater than the combined (SE, CM, DB) preoperative radiographic score $28.51 +/- 2.004$. The Wilcoxon signed rank test showed the difference between the preoperative and postoperative test scores to be significant ($P = 0.0016$).

The difference between the postoperative and preoperative radiographic scores ranged from -10 to 31. Six of 29 dogs had a decrease in radiographic evidence of OA, 1 showed no change, and 22 of 29 had increased postoperative radiographic scores. When the radiographic OA scores were dichotomized for comparison to questionnaire results, 13 of 29 dogs (45%) were assigned to the improved or no changed category and 16 dogs (55%) were considered to be in a worse condition.

The client questionnaires were evaluated. The combined mean generated by the postoperative questions, $259.1 +/- 47.81$, was greater (indicating clinical improvement) than the mean generated by the preoperative questions, $205 +/- 57.47$. The Wilcoxon signed rank test showed the difference between the preoperative client questionnaire scores and the client post-operative test scores to be significant ($P = 0.0002$). The range in values generated by the difference between the postoperative and the preoperative question answers was -64 to 318. Client questionnaire scores did not significantly predict dichotomized radiographic outcome ($P = 0.8482$).

None of the dogs assessed at least 1 y after TPLO surgery was visibly lame at a walk or at a trot.

Discussion

Osteoarthritis is known to occur in canine stifles following cranial cruciate ligament injury (6–9,31). This is especially true for the population of dogs represented in this study with weights greater than 15 kg (10,22). Osteoarthritis is a disorder of joints associated with deterioration of articular cartilage due to fibrillation, thinning, erosion, depletion of proteoglycans, abnormal replication of chondrocytes, osteophyte formation, bone remodeling, changes in periarticular tissue, and low grade nonpurulent inflammation (32). Radiographic changes associated with stifle OA include osteophytosis, enthesiophytosis, subchondral sclerosis, subchondral cystic lucencies, thickening and fibrosis of the periarticular tissues, and joint effusion (21,22,33). Radiographs are a readily available modality for the assessment of stifle OA. Other imaging methods, such as magnetic resonance imaging, computerized tomography, scintigraphy, and arthroscopy, have been described as useful modalities to assess stifle OA (2,33–36). Though these modalities may be more sensitive in assessing joint status, radiographs continue to be the most reported on and the most accessible method of assessing joint disease in dogs.

As in other reports (26,37), interobserver agreement in this study was very high.

Although it has been stated in print and is a widely held opinion that the TPLO procedure stops or reverses the radiographic signs of progression of OA in the cranial cruciate ligament

deficient stifle in dogs (25), a significant progression of radiographic signs of OA was observed in this study in postoperative radiographs compared with the preoperative radiographs at least 1 y after 1 TPLO surgery. To date, 3 other studies have investigated the progression of OA following a TPLO procedure (26–28). Lazar et al (26) found that dogs were less likely to have a large deterioration in OA scores at least 1 y after TPLO than were a similar group of dogs at least 1 y after extracapsular stabilization; statistical differences within each group over time were not reported. Lineberger et al (28) demonstrated a greater progression of OA following a standard medial parapatellar arthrotomy and TPLO than after a mini caudal arthrotomy and TPLO. Direct comparisons with these 2 studies are difficult due to differences in objectives and designs. Results from a study by Rayward et al (27) showed a significant increase in the mean osteophyte score 6 mo after TPLO, though the authors emphasized that 60% of the dogs in the study had no increase at the 6-month follow-up.

The results of the current study were less optimistic. Seventy-six percent of dogs showed a measurable progression of OA, 21% demonstrated a decrease in OA, and 3% had no change. The difference in the results between the studies may be due to the fact that the scoring system used by Rayward et al (27) was restricted to osteophyte assessment alone, while the scoring system in the current study assessed osteophyte production plus bony parameters, such as subchondral sclerosis and lucencies, and soft tissue parameters, such as capsular thickening, effusion, and patellar tendon thickening. Another possible explanation for the difference in results could be the follow-up time. Rayward et al assessed dogs 6 mo after TPLO. The longer follow-up time in the current study may have influenced the final results.

With joint laxity, once cartilage damage has occurred, released collagen molecules in the synovial fluid stimulate an immune response, resulting in a self-perpetuating cycle of inflammation that leads to the progression of arthritis, despite surgical stabilization (8). Many dogs in this study were presented several months after injury and already had evidence of radiographic OA at the preoperative evaluation, which may explain the natural progression of OA seen in the majority of the cases.

Radiographic progression of OA has been reported in 100% of cases after intra- and extracapsular techniques for cranial cruciate ligament stabilization (10,15,16,21,22). Though progression of OA was significant after TPLO surgery, it may be less than that seen after alternative procedures. A randomized prospective clinical study is necessary to prove that TPLO does in fact result in diminished radiographic progression of OA when compared with other techniques.

The answers to the client questionnaire indicated a significant improvement in the postoperative score compared with the preoperative score. The retrospective nature of this study made many commonly used assessments of function, such as serial lameness examinations or kinetic measurements, such as serial force platform measurements, impossible, due to a lack of preoperative controls. The BrOAD client questionnaire was designed as a standard metrological tool for owner-based assessment of outcome following the treatment of cranial cruciate ligament deficiency. Important characteristics of a clinical measurement tool include validity, reliability, and responsiveness. The questionnaire demonstrated acceptable reliability and favorable responsiveness according to Innes and Barr (24), who determined that disease specific outcome measures could be used in owner assessment of cranial cruciate ligament deficiency treatment.

The insignificant correlation between the radiographic outcome and client satisfaction supports the findings of many studies that have implied a lack of relationship between radiographic OA and clinical function. (5,21–23,38).

In summary, the clinical results in dogs at least 1 year after TPLO, as measured by client questionnaire, demonstrated a significant improvement from preoperative limb function. There was a statistically significant progression of radiographic evidence of OA in cranial cruciate ligament deficient stifles from the time of TPLO until at least 1 y after TPLO. Progression of stifle OA was noted in 76% of stifles in this study.   CVJ

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